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# Hydraulic Problems*

By W. Stuart Smith.

THE first difficulty which confronts a would-be promoter, in attempting to develop a cheap power supply, is likely to be an hydraulic one, and as such supply generally has its origin in a water power, the discovery of which is by no means easy when it is coupled with the desideratum that, when developed, some use must be found for the power if the company is to be kept from going through a process of liquidation in consequence of its assets being mainly water.

A suitable water supply having been found the details of its development will depend upon the conditions, such as minimum volume of flow for ordinary seasons; whether the location is such as to insure an annual precipitation sufficient to maintain, at low water seasons, ample supply for the development of the requisite power; whether the power is required for 24-hour service, etc. These conditions will determine whether expensive impounding dams will be required or only cheap wing dams for deflecting the water into ditches or flumes. The building of the dams will generally present no difficulties that cannot be foreseen, though each case will offer its own problems for solution. The cheap production of structural steel in these days will be certain to result in its use in many cases with probably cheapened cost of construction.

Such improvements as are necessary at the initial source of supply having been completed, the next consideration is the means for conveying the water to the point where power is to be developed. For this, two plans present themselves, one employing an all-closed conduit such as a pipe, for the entire distance, and the other making use of an open conduit to a point as near as possible to the power house, the remaining distance being bridged by a pipe by means of which the water may be conveyed with but little loss of head. In connection with the first or all-closed conduit, method, the hydraulic problem presents two opposing factors, each of importance. In favor of the method is the fact that of the head which would be lost in an open conduit, the greater portion could be saved with a pipe, and in case the final head is moderate this saved portion might become of very great importance. The opposing factor is the fact that all such strains as result from the movement of the water are very greatly increased with increasing length of pipe.

Generally the determining factor in the conduit problem is a commercial one, the cost of an all-closed conduit being much greater than that of an open conduit of the same capacity. If the head lost in an open conduit is not a very great consideration, this will generally be adopted and it may take the form of a ditch or flume as circumstances may dictate. Physical conditions frequently determine whether ditch or flume be used since in many cases a ditch is practically an impossibility. The question is frequently asked whether ditch or flume is best but to this query no general answer can be given even when the physical conditions are equally favorable to the construction of either, as other considerations than cost of construction and maintenance may govern. If water is to be had in ample quantity so that saving it does not have to be considered a ditch may frequently be preferable, but with a ditch of great length the loss of water may be enormous and is always an indeterminate quantity. Seepage through the soil occurs everywhere and large quantities will follow unsuspected clefts in rock formations, often appearing as never-failing springs far away from the ditch, also such leakage points may develop where they did not previously exist and great waste may be going on where none is suspected. Careful measurements of the volume of water flowing will show extraordinary leaks to exist between certain limits but exact location and stoppage will necessitate shutting down the plant—a very undesirable thing to do. When the water supply is such that storage reservoirs are required to tide over seasons of small precipitation, such waste cannot be tolerated and the use of a flume may be imperative regardless of cost since this construction permits of easy inspection and, except in case of very serious breaks, repairs can generally be made without shutting off the water. There is the further consideration that the scouring action of the flowing and swirling water is absent.

The magnitude of the proposed installation and the

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effective head on the wheels will determine the advisability or necessity of putting in one or more pipe lines between power house and terminus of the open waterway. If the head is low and the volume of water consequently great, the development of any considerable amount of power will make the use of more than one pipe imperative, but with the very high heads found in many places on the Pacific Coast, a pipe of moderate dimensions will have sufficient capacity for the development of a very considerable amount of power. Good workmanship and careful selection of material in combination with good design will ensure so excellent a pipe that danger of the plant being disabled through pipe failure will be very remote. Large pipes give considerably better efficiency than small ones for the same velocity of flow, a fact which is of considerable importance where water supply is limited, and it is desirable to obtain the highest possible efficiency of the system. Financial conditions may insist upon the first cost being kept at the lowest possible mark, such extensions as are required for the completion of the plant being paid for out of the earnings of the original installation. Again, physical conditions may become the determining factor and difficulties of transportation and laying may demand that a smaller pipe be used than good engineering would sanction, and indeed, the conditions which determine the use of a pipe of moderate dimensions will not be so very severe since the advantages, as to cost, possessed by a large pipe are mainly in labor and since the weight of a pipe with a given factor of safety increases in the same ratio as the volume, i. e., as the square of the diameter.

The improvements in the hurdy gurdy or impulse type of wheel have resulted in the development of water powers under enormous heads and it is generally said that the use of such heads has brought to the surface many difficult and unexpected problems in connection with pipes and requiring much ingenuity and many experiments to overcome. The use of such heads has brought to the surface many problems in connection with the emission and use of the water, but the added problems in connection with the pipe line are few and have been very much overrated. One upon which great stress is laid is that due to the cessation of the flow of water, or the water ram effect, but this is absolutely independent of the head and depends only upon the volume of water brought to rest. It produces a strain of exactly the same magnitude in a pipe carrying water under a head of one hundred feet as it does in one used under a thousand feet, and relatively the strain is very much greater and therefore more dangerous in the case of the pipe under the smallest static strain.

This will be evident if some figures are introduced. A pipe carrying water under a working pressure of one hundred pounds and designed for a factor of safety of seven will have an ultimate strength of seven hundred pounds. If water ram should produce an added pressure of 250 lbs., the factor of safety would be reduced to two. If, however, the pipe is designed for a static strain of 500 pounds and water ram places on this pipe the same extra strain, the factor of safety will be 4 2-3, or with the same water ram the pipe under high head will be 2 1-3 times as safe as the other. Water ram under high heads is a genie which has troubled the Pacific slope since he was released from his Caucasian dungeon, by the too sudden closing of the valve at Fresno which resulted in a strain that was felt throughout the length and breadth of the land. It is probable that but for the bursting of that pipe the question of water ram would have had little general consideration though of course, the hydraulic engineer will consider it in all cases and so order his design as to make it as small as possible. The operator under very high heads has little to fear from it except in cases of such extreme carelessness as resulted in the Fresno disaster, and the appliances for controlling the water should be such as absolutely to prevent such an occurrence. In a plant operating under moderate and low heads the possibility of damage from this cause increases, and in case a long pipe of large diameter is conveying a large volume of water, means must be provided for preventing the sudden cessation of any considerable volume of flow, or, in case the circumstances do not permit this, the pipe must be designed for a much greater pressure than that due to the static head.

As an example of the magnitude this is likely to assume in a particular case, the calculation in connection with the pipe of the Blue Lakes Water Company may be cited. The pipe is about 3400 feet long with a mean inside diameter of about 22 inches. When it is delivering about 1200 h. p., the velocity of flow will be about 5 feet per second. Under these circumstances if the flow of water could be instantly arrested the pressure at the lower end of the pipe due to the inertia of the water would be about 275 pounds per square inch. Screw gates with small pitch of stem are provided so that the closing must be very gradual and the maximum theoretical possible pressure can never be approximated to. Experiment shows very clearly that even if a valve be closed with considerable rapidity, water ram cannot be manifested to a large extent as long as the valve has any considerable opening, the increase of pressure being checked by the escaping water. Automatic valves are sometimes suggested as a safeguard against water ram, but all such appliances add needless complexity and are best omitted. When inertia pressure is likely to add any considerable strain, it is best provided for by increased factor of safety in designing the pipe.

There is another variety of strain which may be set up by the variable motion of the water and which, when the circumstances are suitable for its production, may become very severe. I refer to the vibrations which are sometimes set up in a pipe lying on the surface and carrying a considerable volume of water. These need not be expected to any extent in a straight or but slightly curved pipe, but if a pipe has one or more considerable bends near the bottom and is not thoroughly anchored, the vibrations set up under a variable water flow may be

very severe and in some cases they may be increased by the natural vibration period of the water column coinciding with the period of some rythmic motion at the lower end of the pipe or with some multiple of this period. In all cases where there is a liability to rythmic motion, there is a possibility of a very considerable resonance effect, though this is seldom admitted.

Bends in pipes under very high heads are to be avoided when possible not only because they cause a loss of head by changing the direction of flow, but also because they are unbalanced points in the system which require careful anchoring. Care is always taken to carefully anchor receivers, etc., and yet such bends are frequently neglected, though the necessity for anchoring is as great as in the case of the receiver. With unanchored bends the strain on the flange bolts or joint rivets is much greater than they are designed to carry, and the result may be the opening of joints enough to permit the flow of a small stream. Such stream has great cutting power and with the assistance of swirling sand, may quickly bore an opening sufficiently great to cause the shutting down of the plant. All movements of pipe due to variable motion of water; all expansion due to variable temperature; and all unbalanced strains due to bends, etc., may be eliminated by having the pipe well buried, as the holding power of the soil is very great.

While, under very high heads, the instantaneous stopping of water which is flowing with a velocity which can be countenanced by good engineering, will produce no strain likely to result in rupture, still such strains should not unnecessarily be placed upon the pipe and are best avoided by some form of valve which will not permit of too quick closing. A screw gate fills the requirement, as also does an hydraulic gate provided with necessary safeties, but the Fresno disaster shows that in some hands, safeties may be of no avail unless they are of such a character that they cannot be tampered with. The surest safety is an inlet pipe so small relatively to the cylinder that the travel of the piston cannot exceed a predetermined speed.

For extreme heads, either high or low, the type of wheel will be fixed beyond question, as for very low heads the reaction turbine is the only suitable machine, and for extremely high heads there is no doubt about the advantages of the small circular stream impinging in divided buckets of the Pelton type. For intermediate heads, wheels such as the Knight and the impulse turbines cannot be overlooked as they possess some very material advantages where considerable volumes of water are to be handled.

Of the Pelton type there are now a number on the market differing only in some slight detail of bucket. Some slight variation is necessary as a basis for a new name, but there is probably little to choose between the various shapes, as far as efficiency is concerned. Of far greater importance is the shape of the jet impinging in the buckets, as jets under such high heads are extremely sensitive and a slight variation in the shape of the tip may so alter the jet as to cause a great reduction in efficiency. The best results are obtained from solid, cylindrical jets, but there probably exist more spreading jets than is generally suspected. Every plant should be provided with a tip testing apparatus in which all the conditions under which the tips are to be used are duplicated. This should be placed outside where free discharge can be permitted and easy examination of the jet be made. Without such device the shape of the jet will be an unknown quantity. The valve should be placed so far from the tip that the whirling of the water due to the passage through it may be eliminated and the flow made to take place in lines parallel to the axis before leaving the tip. If this is not done a good jet cannot be expected.

The question as to whether single or multiple jets shall be used will generally be answered in favor of the single jet, when the power requirements are such as to permit it. If a wheel is required to develop a very large amount of power, multiple jets may become necessary, but when a single jet is possible its greater efficiency at full power, coupled with the greater simplicity of a single operating device, will generally decide in its favor.

The housing of a wheel will frequently be governed by considerations which are acoustic and optic rather than hydraulic. With a wrought iron housing the drumming of the water produces, under high heads, a most terrific noise which is largely eliminated by a rigid cast iron structure, also this material lends itself to a more pleasing design than does wrought iron.

Having overcome all the difficulties which opposed themselves to the free passage of the water to the point where it is desired to use it, and having provided a suitable wheel through the agency of which the power stored in the water may be made available, the engineer finds himself confronted by a problem the solution of which has proved to be more difficult than any of the others. I refer to the mechanism for so controlling the application of the water that the speed of the machines may vary through but narrow limits. Water wheels were formerly mainly used in flour mills, saw mills and other places where the load was comparatively steady or where considerable variation of speed was a matter of little moment, and a class of governors had been devised which acted directly upon the gates and were considered sufficiently good if they prevented extreme variations of speed. With the introduction of electricity and the application of water wheels for driving dynamos, governors of this type were found to be entirely useless and many attempts have been made to produce a more satisfactory design. These studies have resulted in the general adoption of the relay type of governor, of which there are several varieties having more or less extended application. They still leave much to be desired but their action is certainly a great improvement over that of governors formerly in use.

While governors of this type have great advantages,

the sensitiveness which gives them their advantage is also the source of a difficulty which can only be overcome by the exercise of considerable care. If dynamos are operating in parallel and the water wheels are independently governed, and if one of the governors has a critical speed which is a little less than the others, it will shut off the water from its wheel until the load is practically carried by the other dynamos, or if there are but two dynamos in operation, one will be overloaded at full gate until the load pulls down the speed to that of the wheel whose governor has the slowest critical speed. This can, of course, be avoided by providing but one governor for actuating the water-controlling mechanism of all the wheels, and in some cases this may be feasible. It is impossible, however, if machines are sometimes to be independently operated on seperate circuits, as this condition will require that each dynamo or group of dynamos be independently governed.

Governing under low heads and great volume of water is also a different problem from governing under high heads with small and sensitive streams, and what is comparatively easy to accomplish in one case will require most careful adjustment for equally satisfactory results to be obtained in the other. The direction of flow of the water particles being of great importance with the small circular stream acting by impulse, almost inappreciable differences in the shape of the tips may result in very different power by different wheels when all gates are opened to the same extent by a single governor, or when deflecting nozzles discharging different shaped streams are placed in the same relative position. If a common governor is to be used in such cases, great care must be exercised to secure similar streams from all the tips. With low heads and great volume of water, the stream is less sensitive and multiple governing can be more easily adopted. Unless it is certain that the machines will always operate in parallel, it is best to provide independent governors having means whereby the critical speed can be adjusted while they are in operation.

Most governors of the relay type operate through change of speed only, but there is another class which, in theory at least, would seem to offer possibilities better than can be found in the purely centrifugal class. This is the class which aims to govern for violent changes of load through the direct action of such change, a variation of speed being anticipated. Two possible cases offer themselves—one makes use of the variable current output of the dynamo through the medium of a solenoid, the variable magnetic action being caused to open or close the valve very quickly, thereby checking the tendency to sudden change of speed, the relay principle being called into action for the fine adjustment. This case finds an example in the Lighthipe governor, which is reported to give excellent satisfaction.

The other case would make use of the tortional strain through the medium of which the power developed by the water wheel is transmitted to the rotor of the dynamo. As in the first case, it would anticipate sudden changes of speed, depending upon the relay principle for nice adjustment. As far as I know it has no working example, but from theoretical considerations it seems to offer better possibilities than any of the other designs.

Finally, the difficulties of governing diminish with increasing load, since any given horse power variation will represent a much smaller percentage of the output and the range of required governing will be comparatively small.

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## WATER WHEEL REGULATION.

By Samuel N. Knight.

During the past ten years there have been many attempts to improve regulating apparatus for water wheels, especially in the case of wheels employed to drive electrical generators where close regulation in speed is indespensable, but the problem becomes of the greatest importance when current for power purposes and for lighting are taken from the same lines.

During the past ten years there have been many attempts to improve regulating apparatus for water wheels, especially in the case of wheels employed to drive electrical generators where close regulation in speed is indespensable, but the problem becomes of the greatest importance when current for power purposes and for lighting are taken from the same lines.

Makers of water wheels and regulating apparatus well know the difference between a long and a short supply pipe in respect to the difficulties of regulation, and on the Pacific Coast we have had the extremes of this difficulty to contend with. In the Eastern states the heads are low and the conduit pipes so short as to scarcely involve the elements of momentum, which is a principal impediment in the West where the heads are usually hundreds of feet and the conducting pipes sometimes miles in length. The ordinary means of regulation are not applicable under these circumstances.

A long pipe filled with water is a moving solid, less elastic and less compressible than steel. It cannot be stopped and started except in a considerable period of time, and, when accelerated, can not be reduced in velocity except by another period of time, varying in common practice here from five to thirty seconds, or in proportion to the length of the pipe line from which the supply is drawn.

It is evident that under these circumstances, common throttling devices would be of no use and that a change of the regulating valve produced by variation in the speed of a water wheel would fail to have effect, so other methods have to be adopted.

Some makers of high pressure tangential water wheels employ what are called deflecting nozzles, by which the water is diverted from the wheel when not required, and its energy is lost. This method obviates the inertia factor in regulation and permits the pressure and flow

in the pipe to remain uniform, but it leads to a waste of water equal to all variations below a maximum load and is too wasteful in any case when water is paid for in volume, or is scarce.

This method is especially objectionable when there are but two or three nozzles of large size, and is less objectionable when there are a large number of nozzles of small size; in other words the loss of water is as its subdivision and as the size of the jets or streams that are cut out and cut in for regulation.

In the case of either throttling or cut out regulation, and when the governing devices are controlled by an electric current from the switch board of a station, either by hydraulic pistons or solenoids, general regulation is easily adjusted by comparing a scale of the indicated horsepower with the watt meter, and the number of jets or issues can be adjusted to give the maximum power required.

In this manner, if the number of issues be five, and the variations of current do not exceed 20 per cent, all regulation will be performed by one issue or nozzle, and any loss of efficiency in this issue due to throttling would be divisible by five, so the losses of regulation would be inconsiderable.

This method does not, however, provide for inertia and momentum in the pipe line, and at the works of the Pioneer Electric Power Company of Ogden, Utah, where the pipe line is six miles long and six feet in diameter, the periods of change in the flow of water are supplemented by heavy fly wheels, that give out or absorb energy during periods of change. In this plant of 6,000 horsepower are surmounted perhaps the greatest difficulties ever encountered in respect to regulation, the latter being provided for in several ways, one of which is by over-flow or relay stand pipes designed by Mr. C. K. Bannister, chief engineer of the company.

These stand pipes, one of which is within one mile of the station, perform the functions of an air vessel, except that the resistance is as the gravity, and the motion is as the square root of the head, and in these respects it differs from the action of compressed air. The stand pipe mentioned, in effect, reduces the pipe line to one mile in length, but even this mass of water, weighing more than 4,500 tons, has to be handled with care. Its properties as to motion can be imagined by comparing it with a large ocean steamer, and how such a steamer could be moved backwards and forward to adjust the speed and energy of a water wheel.

Fly wheels placed on the water wheel shafts have to withstand an enormous speed of revolution, the strain exceeding the limit for cast iron, but within the strength of the best mallable metals, such as fibrous iron and alloys of certain kinds too well known to need mention.

The writer, who was the contractor for and constructed the hydraulic power equipment in the Pioneer Electric Power Company's plant at Ogden, adopted a form of regulating apparatus that was intended to form the principal subject in this paper.

This apparatus, of which there are five sets, are applied to as many water wheels giving out 6,000 horsepower. Upon inspection it appears to be an extensive and somewhat complicated device, but it contains only the elements required to perform the necessary functions to insure regulation under the extremely difficult conditions I have been pointing out. It is, of course, impossible in words alone, or even with the aid of drawings, to fully explain the mechanism and the particular manner of its operation. The best I can do is to describe in general terms the main elements and the principal on which they operate.

The Knight governor contains two centrifugal governors, driven at the same speed from one shaft. When the speed of the generators change, one governor acts by closing an electric circuit communicating to a magnet, or solenoid, that by means of a lever, engages a friction clutch and sets in motion machinery driven from the main shaft that opens or closes a throttling valve, or the induction issues of the water wheels. The electric circuit and action of the solenoids is not constant, however, if so the regulating action would outstrip the change in the motion of the water in the pipe line, so the electric circuit established by the governor's action is broken intermittently by a relay, the action on the water being confined to one-sixth of the time.

If under these circumstances the change of speed in the water wheels and generators is not accomplished by the first governor, the second one comes into action, and also closes the electric circuit to the solenoid, which current is also intermittently broken, but at longer periods corresponding to one-third of the time. In other words, the action on the water regulating apparatus is doubled by the second governor, if however, as is possible under extreme changes, this intermittent action of the regulating apparatus does not produce the required change of motion in the wheels, a third contact is made by the second governor and so the current and action of the solenoid becomes constant until the speed is checked or accelerated to meet the load or resistance.

This in general terms is the method of operating, carried out successfully in the case named, which is one of the most extensive installations in the world and certainly one where the impediments to be dealt with have no parallel in modern practice. Had the regulating apparatus been given a free range and continuous action between the extremes, the result would be destructive racing and no useful results could be attained.

In this case the adjustment of the electrical elements provide for twenty-four changes of the rate at which the clutches and water regulating gearing may operate. In other cases this range of adjustment can be less and the regulating mechanism as a whole be simplified, the mode of operating remaining the same.

I may mention that while the plans and construction of this regulating apparatus involve a good many intricate problems, these have been less difficult for the writer to deal with than this attempt to describe the work.

# Protection Against Lightning

PAPERS READ BEFORE THE SACRAMENTO CONVENTION OF THE PACIFIC COAST ELECTRIC TRANSMISSION ASSOCIATION. SACRAMENTO, CAL., OCTOBER 22, 1897.

## LIGHTNING ON TRANSMISSION LINES.

BY THEO. E. THEBERATH, M. E.

BEFORE taking up the question of protection, allow me to touch briefly on the question of what lightning is and what are some of its properties. You are all familiar with the phenomena of lightning as it is seen during a storm, and I have no doubt many of you are familiar with its effect on electrical apparatus, both from a practical as well as a financial standpoint. It has long been an established fact that lightning is an electric phenomena and that it is the result of an accumulated charge of the character known as static electricity.

Static electricity, as its name implies, means electricity standing still and is a term used to distinguish it from dynamic electricity or electricity in motion. Lightning on a small scale was produced by the old experimenters in various ways, and as early as 1602, Otto von Guericke cast a sulphur globe in a glass sphere and then broke away the glass and he found by rubbing the globe with the hands, as it revolved upon an axis, that light and sound resulted from strong electrical excitation. Later Sir Isaac Newton used a glass globe for the same purpose. The source of energy of this miniature lightning in the above case was hand power applied to the crank handle used to revolve the sphere.

It is an undisputed fact that a stroke of lightning represents the expenditure of considerable energy, as evidenced by its destructive effect. The source of this energy is still an open problem and an attempt at its solution immediately leads one into the still unknown realms of that which is supposed to permeate all space and known as the "ether." It is considered that in all probability the whole Universe, or at any rate that part of it at present known to us, which extends for more than millions of miles away on every side of the solar system, is filled with a jelly like substance called "the ether" sometimes "the luminiferous ether." While the existence of the ether is a generally accepted theory, its qualities are but little known. Assuming certain quantities, Lord Kelvin gives its rigidity or resistance to bending as one one hundred and fourteen thousand million millionths of that of steel; its density in space about one hundred and twenty-eight ten-trillion trillionths that of steel. In all matter its density is somewhat greater than this, and in iron its density is much greater. Numberless explanations of the origin of lightning have been suggested and the liberty is taken here to add to the number; as a proper understanding of the properties of that against which we desire to protect may lead to a better understanding of the conditions to be met and the means to be applied to accomplish the desired object.

Taking our earth with its enormous surface of nearly 200,000,000 square miles revolving on its axis at the rate of 1035 miles per hour, and at the same time traveling around its orbit at the rate of 1800 miles an hour, and comparing it with the spheres of Guericke and Newton, we can form a comparative conception of the relative results obtained in the shape of an electrical excitation, and the resulting discharge therefrom. It is true that Newton and Guericke applied their hands to the revolving globes and that these conditions are lacking in our earth, as a static electric accumulator. Franklin showed about the middle part of the 18th century that electricity is not created by friction, but merely collected from its state of diffusion through other matter by which it is attracted. The earth however, is traveling through the ether which has rigidity and density, and as Lord Kelvin has stated, the density of ether is greater in matter than in space, we can consider a concentration of ether in the path of our earth, similar to the concentration of lines of magnetic force in the permanent or electro magnet. Furthermore, owing to the rigidity of the ether we can consider our earth traveling through a viscous medium. The rate of speed being greatest at the equator, there is an accumulation, so to speak, at this point and in consequence of the lower speed at the poles, this tendency is not so marked and a vortex or whirl is set up. This therefore sets up a difference of potential between the equator and the poles, and a consequent flow from the equator to the poles. That a re-distribution takes place at the poles is evidenced by the fact that when the conditions of the earth's atmosphere are favorable to harmonizing with the vibrations of the departing ether, or the interference of the atmosphere breaking up the wave lengths of the vibrating ether, the result is the sensation of light known as the Aurora.

From various experiments, such as were carried on by Franklin and others in the early days and also those carried on lately by the United States Weather Bureau with kites of the Hargrave pattern we can see that the redistribution of the ether takes place not simply along the surface of the earth, but that there is a movement of the ether through the atmosphere. Any surface, therefore, which is capable of receiving a charge, or in other words, any surface which will interfere with the free passage of the traveling waves or vibrations, if interposed in the path of these vibrations, will become charged with a difference of potential with reference to surrounding points.

The experiments of the United States Weather Bureau with the Hargrave kites prove this to be the case even in clear weather with a clear sky. It has therefore been clearly demonstrated that there is in existence what has been termed "atmospheric electricity."

It seems strange that we should have phenomena of static electricity of vast proportions under conditions which seem absolutely adverse for the existence of accumulated charges of static electricity; as it is a well known fact that in the laboratory experiments with influence machines in the production of static electricity, better and more marked results are obtained when the air is crisp and perfectly dry. Then why should we find in nature the existence of enormous charges of static electricity accumulated under most adverse conditions and produce discharges through an atmosphere not only moist but decidedly wet. This condition however, is easily accounted for when it is known that a drop of water can be electrified and retain a surface charge. It has been observed that sparks discharge from rain drops as they approach the ground. Snow flakes have been found to be charged, as shown by sparks drawn from an umbrella on which snow has fallen. As the water is evaporated from the surface of the earth and carried upwards through the air, it is gradually condensed from the gaseous to the liquid state by coming in contact with the upper strata of air which are cooler than those in the neighborhood of the earth's surface.

The small particles of water formed by this condensation unite together and form clouds, or if the temperature is low enough the vapor is frozen into a mist. In either case surfaces are formed which are capable of receiving a charge of electricity, or an accumulation, with a resultant difference of potential of such magnitude that it finally overcomes the intervening resistance and a discharge takes place with a rapid re-distribution or equalization of potential.

The theory advanced is thus briefly stated; that the motion of the earth through the ether is the cause of the accumulation of the energy producing the phenomena of lightning.

The clouds act as an interfering medium to the natural re-distribution of the accumulated energy, which is going on constantly. The disruptive discharge is the result of the difference of potential which is created when a charged body is brought in the neighborhood of another body, which in turn becomes charged in the opposite sense and thereby increasing the difference of potential until an equalization is brought about by its rapid dissipation of energy in the form of light, heat and sound vibration. We can practically consider the clouds and the earth's surface as forming two plates of an enormous condenser with the air as the dielectric between them.

In experiments with condensers it has been found, as stated by Prof. Sylvanus Thomson, "That if the termin-
"als of a charged condenser are connected by a high re-
"sistance, such as a nearly dry linen thread, the charge
"simply dies away by a discharge which increases its
"strength at first, and then gradually dies away. If,
"however, the condenser is discharged through a coil of
"wire of one or more turns (the spark being taken be-
"tween polished knobs to prevent premature discharge)
"the effect is of an entirely different character, for then
"the discharge consists of a number of excessively rapid
"oscillations or surgings. The first rush more than
"empties the condenser and charges it the opposite way;
"then follows a reverse discharge, which also overdoes
"the discharge, and charges the condenser the same way
"as at first, and so forth. Each successive oscillation is
"feebler than the preceding, so that after a number of os-
"cillations the discharge dies away."

That lightning follows the above conditions has been demonstrated in various ways. The air as a general rule is charged positively with reference to the earth, but, during storms, negative electrification has been noted as well as severe disturbances in the atmospheric electricity. During this surging back and forth of the ether, all surfaces in the path of the moving ether, become charged; if these surfaces are well insulated from the earth, such as the wires of a long distance transmission circuit, we may have static discharges from the wires even when the primary discharge occurred some distance from the pole line. If the line is well insulated from the cross arms and poles, as is necessarily the case with high potential circuits, the strain is transferred to the insulation of the transformers or generators and any weak spot in this insulation will allow the stored up energy to rush to earth with resulting damage to the apparatus.

It is therefore self evident that all that is necessary to protect our apparatus is to provide an easier path to earth for this stored up energy and in this way relieve the line of the static discharge. A ground connection with a spark gap interposed, is all that is required as far as the static electricity is concerned; but the gap once closed by an arc formed by the static discharge will allow the dynamic current to follow in its path and a short circuit will result if the discharge has taken place from both wires of the circuit.

While the means for relieving a line of its static charge is a very simple problem, the elimination of the short circuiting of the dynamic current is not so easily accomplished. Many ingenious devices to accomplish the opening of the short circuit produced, have been invented and placed upon the market. Some of these depended upon moving parts, but owing to the fact that lightning is not an hourly occurrence which would keep them limbered up, they were generally found out of order when the time came for action. The requirements for a good lightning arrester are as follows:

1. It must offer an easy path for the passage of the static current.

2. The spark gap must be small enough to allow the charge to dissipate itself before reaching a potential which would endanger the insulation of the translating devices.

3. It must prevent the following of the dynamic current.

With reference to the first requirement it has been found that in all experiments with static electricity, in order to get good results, the spark gap surfaces should be clean and bright. As soon as the surfaces become blackened and pitted it is found necessary to raise the potential considerably in order to get the charge to leap across the gap. It is very essential, therefore, that the arrester be so constructed that a large sparking surface is presented so that the care and necessity for inspection is reduced to a minimum. This property is a most desirable feature for arresters in connection with high voltage circuits and which are not desirable subjects for constant handling when the current is on the line.

In the selection of the proper spark gap it is necessary to take in consideration the quality of the insulation of the translating devices, the distance through which the static discharge can take place and at the same time providing against the establishment of an arc by the dynamic current. If the insulation of the translating devices is poor in connection with too large a spark gap, the translating device may act as a better lightning arrester than the instrument intended for that purpose.

Lightning arresters with moving parts have been entirely abandoned by nearly all manufacturers, and it is therefore unnecessary to dwell upon their construction. The style of arresters which are giving the best results at the present day, on alternating current circuits, are of the non-arcing metal type. The special feature of this type of arrester is the use of metallic cylinders or spheres, placed side by side with an air space or sparking gap between them. The number of cylinders or spheres and air gaps are proportioned with reference to the difference of potential of the dynamic current used on the line. The cylinders or spheres are constructed of a metal whose oxides are intended to produce non-conducting vapors. The metals which possess this property are of the well known chemical group of antimony, zinc and cadmium. Zinc, on account of its being the least expensive of the group, is commonly used, and in fact ordinary brass possesses all the properties of the so-called non-arcing metal. It has been found in practice however, that the non-arcing metal will arc at times and cause a short circuit on the line. This may have been due to the use of too much copper in the original mixture or it may have been the result of several discharges having passed between the same points. Under this condition the surfaces adjoining the spark gap may have been reduced to a copper surface and the resulting vapor having conducting instead of non-conducting properties. To avoid the above conditions it was found advisable to turn the cylinders after a discharge had passed over the gap so as to present new surfaces. Short circuiting has also resulted from insufficient insulation between the terminal points for the line connections. In some of the arresters the terminal connections are placed on a marble or porcelain slab with its surface in a horizontal position. This arrangement allows the accumulation of dust and dirt upon the surface and a short circuit between the terminals may be the result. The danger of short circuiting the terminals is generally encountered in the use of a single arrester on one or two thousand volt circuits; as in this case the potential strain of the circuit is brought at the two extremities of a horizontal surface of marble which acts as a dust collecting shelf.

Arresters using the non-arcing metal principle have been constructed in various ways with reference to the shape of the surface presented to the spark gap. The universal custom of using metal balls as discharging surfaces in all experiments with static electricity led to the construction of an arrester composed of a number of spheres or balls of non-arcing metal mounted on insulating material, with spark gaps between them. While this style of surface is well adapted for use in connection with purely static discharges, it is absolutely useless where a static discharge is liable to be followed by dynamo current. The sphere presents only two points as the shortest distance between their surfaces. A single discharge will blacken these points and the second discharge must be of a higher potential, to either overcome the greater resistance of the oxidized surfaces or the resistance of the greater air gap between the clean or un-oxidized surfaces.

The arrester using parallel cylinders has an advantage over the sphere in the fact that the air gap is of the same length for the whole length of the two parallel elements of the cylinders and a greater number of discharges can pass over the air gap before the resistance of the gap is increased by the complete oxidization of the surfaces.

An arrester has been designed recently which consists of a series of concentric cylinders with flaring tops; the cylinders are held in place by perforated porcelain caps. The air gaps between the parallel sections are of such length that the e. m. f. necessary to spark the gaps is less than the e. m. f. necessary to rupture the insulation of the system. The arrester consists of two portions, each being held in place by separate porcelain pieces. The line terminals are connected to the center post in the center of the larger porcelain caps. The insulation of the terminals is very high with this arrangement, and it is impossible for the accumulation of dust or bugs to start an arc between the terminals.

It is very apparent that with concentric cylinders the greatest surface is presented to the sparking gap and a larger number of discharges can be taken across the gaps before it becomes necessary to change the cylinder. The air gap is of the shortest length at the bottom end of the cylinders and at the point of flare the space between the conical surfaces gradually increases. The static discharge will leap across the gap at the narrowest point, and the natural draught of air set up by the heat of the arc causes an upward travel of the arc, along the increasing air gap until the interruption of the dynamo current takes place.

This arrester combines the non-arcing principle with

a natural air blast to rupture the arc. Three concentric cylinders are used with three air gaps forming a unit for one thousand volts, and for the higher voltages a number of these units are connected in series.

In connection with the lightning arresters it is advisable to insert self induction coils in the line between the point of attachment of the arresters and the apparatus to be protected. Owing to the fact that lightning discharges are of a pulsating nature of very high frequency, it has been found, that a small amount of self induction, in the shape of a few turns of wire, will offer an impedance, sufficient to force the discharge to take place to earth over the path of the lightning arresters instead of the path through the apparatus.

The introduction of self-induction in an alternating circuit is an undersirable feature as it assists in lowering the power factor. The objection to the use of impedance coils has been removed in a novel way in one of the recent installations of the Stanley Electric Manufacturing Co. In this case two self-induction coils are connected in opposition to each other in the same leg of the circuit. This is found to practically eliminate the self-induction as far as the dynamo currents are concerned, but at the same time offering high impedance to the current of the static charge. This method is better and safer than the one used by Bradley, which consists of two coils, one in each leg of the circuit, and so arranged that the outgoing and returning current neutralizes the self-induction in the coils. This is a difficult arrangement to insulate for high voltages.

Lightning protection should be installed at each end of a long distance transmission line and at the terminal points of all its branches. If the line passes through a section of country where lightning is of frequent occurrence it would be well to protect the line at the most exposed points.

The old saying that "An ounce of prevention is better than a pound of cure" applies admirably to the case of protection against lightning discharges. If it were possible to keep the earth, and other surrounding objects in the neighborhood of the pole line, constantly discharged, or in other words, prevent the clouds from charging the line and surrounding bodies with a difference of potential, all danger of damage by lightning would be eliminated. A barbed wire, well grounded, strung over the top of the poles will assist in keeping the ground and the line discharged, but this should not be depended upon as the only method of protection. A plentiful supply of line aresters, well placed on the distribution circuits will afford protection to the transformers scattered along the line.

Owing to the oscillatory and surging nature of the charge on the line, it has been found that nodal points are established and that the discharge is somewhat selective in its nature. For this reason it has been found advisable to arange the banks of lightning arresters on high potential circuits in such a way that several paths are offered. As an example of this consider two impedance coils connected in opposition to each other and in series with one wire of the circuit. From the point of connection between the two coils and their extreme ends, take off three taps to three 1000 volt units; then connect these three units to two, and then continue with single units of sufficient numbers to equal the voltage of the system. Then connect the ground terminal of the last unit to a good earth by means of a galvanized iron strip, clamped between porcelain cleats. The advantages of a galvanized strip are, that a flat surface is a better conductor for static charges and the flat iron ribbon offers resistance to the passage of the dynamo current when mounted in the way specified as above.

## LIGHTNING AT SACRAMENTO.

By C. W. Hutton.

According to some recent estimates, the losses to electric companies, due to electric discharges, are between $250,000 and $350,000 annually. Although the subject of lightning and methods of protection has received a great deal of attention in the past ten years, the above figures would tend to indicate that there is still considerable room for improvement. The fact that there are so many electric transmission plants that have sprung into existence in the past two years with their long, exposed lines; high potentials; large powers, and with the immense amount of money that is invested in step-up and step-down transformers that are directly but unavoidably connected to these long, exposed lines, makes the subject of protecting the apparatus against outside influences of still greater importance.

The function of a lightning arrester in any electric installation is to relieve the conductors of any excessive electric potential differences that may exist between them and the earth, and at the same time prevent an excessive flow from one conductor to the other, should there be a simultaneous discharge over any two conductors differing in potential.

In the case of a distributing circuit, where apparatus is promiscuously connected along its entire length, a single set of arresters at one end or at both, no matter how perfect in construction and operation they may be, would not of necessity protect the connected apparatus. The reasons for this are not obvious.

In the language of a well known authority: "That which we see and call lightning, is not a simple passage from cloud to earth; it is a vibration; the lightning oscillates back and forth. The oscillatory character of lightning and of disruptive discharges in general give rise to complicated phenomena. Electric oscillations or waves interfere with each other much as water waves interfere with each other. If, for example, a trough of water be raised at one end and then quickly lowered, the water in the trough will quietly surge back and forth.

If the end of the trough be raised a second time, a new system of surging may be started, and in such manner that the two will interfere with each other, and cause splashing at certain points, where crests of the two systems combine to form higher crests. Calm or smooth places will be noticed at points where a crest of one system has been neutralized by a trough of the other system. In electric wires we have somewhat analagous conditions during thunder storms. We have what a sailor would call a 'choppy sea.' The calm places and the splashing places are very close together, so that a lightning arrester connected anywhere in the line may, for aught we know, be connected at a calm place or at a splashing place.

It is obvious, then, from this, that the only effective way to protect a distributing circuit is to have enough arresters connected and distributed along the line, that for all conditions some of them shall be found at the crests where the disruptive discharges take place. It has been found by experience that the ends of the circuits and the ends of the branches are the parts subject to the greatest danger of burn-outs. At one plant in the City of Columbus, Ga., where a great deal of trouble was experienced from lightning discharges, it was found that in every instance where a transformer was connected at the end of a branch or circuit, it would invariably be burned out in the first storm. Bearing in mind that the ends of the lines were the parts most effected, the difficulty was remedied by running the lines one or two spans by the transformer, and tapping in a lightning arrester at the end. Even the arresters had a hard time of it, and a great many of the older type were burned out. Since substituting a later and improved type of arrester, and cutting in choke coils between the transformer and the line, no burn-outs have occurred.

In the case of the transmission lines, the conditions are somewhat different, as the apparatus is usually all at the ends, except the poor insulators, and, for aught we know, those poor insulators may be in the same condition that the country was a year ago—perhaps protection would exert a stimulating influence. Who knows but that during damp weather, while these high potentials are being generated in our long overhead lines by simple disturbances of the atmosphere, many insulators are punctured, and in the midst of the first storm the current takes advantage of the weak insulators, the pins are burned off and the insulators topple over. We say that these insulators broke down under a strain of 10,000 volts. Who knows but that it was subjected to perhaps several times that amount? It would appear, however, that the ends of the lines are points that need the most protection, and, as far as I know, as at present constructed, all transmission lines are protected at the ends only.

The experiences of the Sacramento Electric, Gas & Railway Company, with lightning have been very trifling—five shut downs are all that can be charged to lightning effects. Three of these occurred before the installation of the arresters at either end, and the effect of two of these was simply to throw the synchronous motors out of step, and in the early days of the plant, the slightest disturbance of any kind was the signal to shut off the current, and find out by telephone if everything was all right at both ends. No damage was done on the occasion of two of these shut-downs, and there was but a few minutes delay each time. The third one, however, caused a two-hours' delay. The lightning came in, and in some inconceivable manner, jumped from the high tension to the low tension side of the step-up transformers without even leaving a visible trace, and then went down the back of the generator board and burned off all of the voltmeter and synchronizing switching apparatus, and the plant was shut down two hours to make repairs. Since the installation of the arresters, there have been two shut-downs. These occurred before any resistances had been cut in series with the arresters, and when a discharge took place, the heavy current that followed dropped the voltage to such an extent that the motors, while under load, would fall out of step, but, as in the former cases, no damage was done, and only a few minutes delay was the result. Since the installation of the arresters and the resistances complete, very little trouble has been experienced.

On the afternoon of August 18th last and the morning of the 19th, quite a number of discharges took place, and especially on the morning of the 19th, there was quite a severe storm, and the discharges took place in quick succession, there being as many as fourteen in thirty minutes. The only effect, however, was simply to wink the lights and cause some slight churning in the speed. A volt-meter card was taking showing the effect of these discharges. Of course the throw of the needle was considerable, and would not, therefore, show accurately the drop of potential, but it shows how effectually the arresters took care of the discharges.

On the night of October 5th of the present year, the plant experienced an ugly shut-down, but its cause, I think, cannot be attributed to lightning. The lightning arresters, however, were very badly burned. The trouble happened in this way. The synchronous motors fell out of step, and the arresters flared up terribly; flashes came out of the telephone, and communication with Folsom was broken. When this happens, the man in charge at the generators is instructed to keep current on the lines if possible, so he kept pumping into the lines for about ten minutes, and seeing that something unusual had happened, he finally shut down. During the trouble, however, the dynamo tender at the Sacramento end commenced pulling the high tension swithces, and in so doing an arc was formed that burned off one set of wires that run into the switchboard from the north pole line. After current was cut off, the telephone worked all right and the man at Folsom was told to start up on the three remaining circuits, as there are four complete circuits altogether—two on each pole line. Still there was trouble on the lines, and word reached the station that a wire was down in a certain street and was making klink-

ers out of the gravel. In the meantime some of the arresters and resistances suffered severely. Some of the arrester balls were fused together and the resistances burned out. This is accounted for from the fact that when everything is intact, that there are two resistances and two arresters in series between any two wires, and in this case with one wire on the ground the arrester and resistance connected to this line would be shunted, leaving only one arrester and one resistance with the full potential of 10,000 volts across it, the consequence was that the arrester could not break the arc that formed, and the result was as indicated. The two circuits, one of which was grounded, were on this line of poles, and were cut out and we were ready to start on the one remaining circuit on the other pole line. We were delayed, however, as all the telephone apparatus of three distinct lines was knocked out and we were shut down one hour and ten minutes, instead of thirty-five minutes, as we would have been had the telephone worked properly. The cause of the line burning off was that some twigs of a tree had blown over against the wires, and it is my opinion that an arc was sprung between two neighboring wires, causing one of them to burn off. It is hard to say certainly that it was a "short" that burned off the wire. It may have been done simply by the twig coming in contact with the wire alone, but the neighboring wire shows quite a burn, and when the lights first went down they seemed to hover for a few seconds, and it looked as though there was a "short" through some very high resistances. It is, therefore, presumed that a "short" did the mischief, and not the mere grounding of the wire by a damp twig.

## LIGHTNING IN NEVADA COUNTY.

By E. J. De Sabla, Jr.

BRIEFLY our troubles with lightning discharges on the transmission circuit of the Nevada Co. Electric Power Company have been comparatively few. However, I will endeavor in a few words to give our experience in the matter.

We have two Stanley 360 kw., 16,000 alternation generators, delivering 5,500 volts directly to our lines. The arrangement of the wires on our pole line is as follows: Poles are set 106 feet apart and carry two four-pin cross arms, eighteen inches apart, and two brackets six feet below the lower cross arm. On the tops of the poles is run No. 6 B. and S. galvanized iron wire, spiked to the wood with long wire spikes clinched over the wire; the ground-connecting wires on every other pole are soldered to the main wire and stapled to the side of the pole, also soldered to the ground plates, which are sheets of galvanized iron three feet wide wrapped around the butts of the poles. The pins in the cross arms are eighteen inches apart, on which are placed Locke triple petticoat porcelain insulators, on which are run the transmission wires, each one eighteen inches from the wires each side and the one below. The eight wires give us two complete circuits of four wires each, and each phase of two independent wires which are carried to all parts of the system. The brackets above mentioned carry the telephone line each side of the instrument, was found to give ample protection, but had to be repaired after each discharge.

The first thunder storm we experienced after starting was in the latter part of May, 1896, early in the morning. The discharge mistook our static ground detectors for arresters, and as we had failed to protect them by suitable fuses, the result was a dead short circuit and the destruction of one of our instruments. At that time we were using only one circuit and had only a lighting load. The strange part of this experience was that only one phase was affected, and that one was nearest to our ground wire, and we would think ought to have been least disturbed, the other phase not being disturbed noticeably. After this we decided to install lightning arresters in double bank at each terminal of the line; viz., at the power house, at each sub-station, and at each large motor outfit.

When the second thunder storm came in the latter part of September, 1896, at 4 P. M., we had but one motor in operation; viz., a 120 kw. two-phase synchronous motor operating an air compressor; we also had about 3,000 lights connected at the time. Both our generators were running independently, one on the power circuit, the other on our lighting circuit; the extra arresters had been installed at the two sub-stations, but not at the synchronous motor. Each discharge produced a momentary short circuit, caused evidently by the discharge passing the arresters. About the third time this happened, the synchronous motor dropped off when the circuits were thrown in parallel at the power house on to one machine; the next discharge produced a heavy short circuit, and the machinery was stopped, but started again in a few seconds, everything being apparently all right; but our Grass Valley sub-station soon signaled to shut down, it being found that the current had jumped across the open terminals of the phases at both Nevada City and Grass Valley (as all of the wires had been connected to the board so that the lighting load could be carried on either circuit). The burned marble was scraped clean and the storm having passed, the plant was started up, having been shut down only a few minutes.

It was found later that all the terminals of the synchronizing transformers for the large motor had been burned off, and that all the fuses on the starting motor transformers were blown, but aside from the small transformers no serious damage was done. No arresters had been put in for this motor, and hence the trouble. The next trouble came the last day of February, 1897, when we lost a 300-light step-down transformer at the Nevada wires, which are transposed every fifth pole.

It was thought at first that ample protection would be given by the heavy iron wire described above, but some

weeks before starting the plant we had our telephone instruments badly damaged by lightning; this experience brought out the importance of more protecting devices, and a single set of Wurtz non-arcing out-door arresters were installed at the power house and arranged as the manufacturers directed, using an impedance coil of wire wound seventeen turns on a three-inch gas pipe. We supposed that the telephone line, being so far below the iron wire, would be thoroughly protected, but as stated the telephone system suffered from the start. To protect our instruments until we could install something permanent, a three-fourths inch iron bolt connected to the ground was wound with two or three thicknesses of paper and over this a half dozen turns of copper wire in the City sub-station, causing a shut-down for a few minutes.

The iron wire before mentioned got itself into disrepute by coming loose from its fastenings and grounding and short circuiting the lines at the most inopportune moments, so that it needed very little coaxing on the part of the electrician to get permission to cut it loose from the ground entirely, it being left in shape so it could be connected up conveniently if thought necessary. As a result we have a much improved telephone service, and some saving in power; we also note that we have had no telephone damage since the change. The electrician is not entirely vindicated yet, however, for in August last, we lost a 500-light step-down transformer at Nevada City during a thunder storm. However, this transformer had been seriously strained when it was first put into service, and had for many months been doing double duty. It is thought that our troubles from this source are aggravated by the fact that the lines cross the streams at right angles, and that there is an excessive difference of elevation between points on the line only short distances apart. For instance, at the power house the elevation is 1,400 feet, twenty poles from the power house it is 2,600 feet. The only fact that gives any permanent color to this theory is that we have five miles of line running from Grass Valley down the ridge to our arc plant purchased from the former lighting company in Grass Valley, which plant we still operate) and has never to our knowledge been disturbed by discharges, and has no protection whatever; this old line carries two arc circuits and a telephone circuit.

The thunder storms we have experienced come down from the mountains and although we do not know their tracks definitely, some pass the power house, spending their energy before reaching it, and others pass below or near Grass Valley, very few having passed Nevada City.

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**"Permit me to express my pleasure in reading the Journal of Electricity. You are furnishing us with an admirable paper and I trust you will prosper in the enterprise and continue to favor us, especially with illustrated descriptions of long distance transmissions."**
**—W. M. Stein.**

## LIGHTNING AND LONG TRANSMISSION.

By E. W. Sutcliffe.

IT would almost be possible to treat of our theme as did the historian of Ireland, who, when he came to his chapter on snakes, in his general description of the resources of the Emerald Isle, began and ended the matter by simply saying: "There are no snakes in Ireland." It is almost true that we have no experiences.

Hence, of information concerning the freaks of lightning, as drawn from our own observation, there is little to impart. Lightning along our lines is infrequent and seldom violent. Only one severe electrical storm has swept over us, and the damage it wrought was insignificant.

Let us premise that we are protected by Westinghouse apparatus, the power house at Newcastle and the sub-station at Sacramento being guarded each by a battery of eighteen choke coils and one hundred and twenty-six non-arcing cylinders, forming type C, lightning arresters. This is on the high potential transmission line. At the sub-station, circuits going into the distributing system are equipped with one double pole non-arcing line arrester for each wire, but with a common ground for each pair.

Our wires have been struck several times, and we have seen and heard the discharge, as it danced across the arresters with a crackling noise; but it has always made its way safely to the ground.

Occasionally we have found that coincidently with the discharge the speed of the station motors, which drive arc dynamos, has increased 10 to 15 per cent.

On one occasion, during the very severe storm alluded to, our lines were struck near Newcastle, and the lightning formed an arc in the power house across the arresters, and the machine current held it there until the voltage was dropped. The same ocurrence repeated itself about five hours later, the arc holding out for several seconds. During the same day of unusual electrical disturbance, a discharge at the sub-station in the city blew the fuses at the power house in Newcastle, and momentarily shut down the plant. It looked as though the current were dammed back and found relief twenty-eight miles away in the melting of the fuses.

We consider the discharges on our long transmission line not nearly so severe as those we have observed on street railway lines in regions no more exposed to lightning, in California; which fact we deem to be owing to increased facilities on an extended pole line for dissipation through poles, trees, etc.

We consider our arresters efficient and feel ourselves well protected, the only visible result on our protective apparatus so far having been a slight blackening of the metallic cylinders.

On our secondary circuits of 2200 to 2400 volts, we have had no trouble that we can certainly attribute to lightning. Two converters have been lost during storms

under supicious circumstances, the insulation of the primary coils having been pierced at one point by a hole only one thirty-second of an inch in diameter. No effect was noticed at the station; and we conclude that if lightning on the city lines has ever discharged in the central station, it has been safely grounded by the protective apparatus.

We propose the following queries:

Can lightning produce the damming back of a current and a rise in voltage at generating point analogous to the bursting effect of a sudden shutting off of water under momentum in a pipe?

If so, why have not our city sub-station fuses been blown when discharges have entered our distributing lines?

Might not this damming back of current sometimes prove as bad as a direct grounding of the lightning through the machines?

Is a longer transmission line in greater danger on elevated portions of the country than on those which lie lower?

Is there any feasible, simple method of protecting transformers, scattered over the distributing system?

## INSULATORS FOR TRANSMISSION LINES.

By John Martin.

ONE of the most important questions which presents itself to the engineering fraternity who are exerting their efforts to utilize the vast water powers in this State and elsewhere, that have been for ages wasting their energies in wearing away rocks and washing mud and sand to the lower levels, is the problem of insulating the line wires of a transmission circuit so as to withstand the severe strain of the higher potentials which are now being used in order to bring nature's bounteous energy from the distant mountain ranges to the assistance of struggling humanity, and to enable them to cope more successfully with the ever-present problem of economics that is being forced upon them by the gigantic march of progress throughout civilization. The generation of high potentials has been brought to a state of perfection, and while it is a question of insulation, the conditions encountered are perhaps more favorable than the insulation of a wire which is exposed to the elements.

In the early days of electric transmission, when the power house was always located as near the center of distribution as possible, the ordinary glass insulator, which had been designed for the low potential service of telegraph work, was found all sufficient to give proper insulation to the fairly well insulated wire used in constructing these circuits. When, however, the potential of the circuit is raised into the thousands of volts, the wire with ordinary line material becomes a case of "paying too much for the whistle," and the money expended in paying for a complete coating of insulating material at the price of copper per pound had better be expended in a higher grade of supporting insulator which will protect the line at its most exposed points.

We are living in an age of progress, and intercommunication with the old stage coach, while it still exists here in this State and elsewhere as a matter of necessity, is no longer the only means of bringing the population of widely separated sections in touch with each other. The extension of our railroads, with the constantly increasing train speed and the vast increase in traffic, made it desirable and necessary to comunicate rapidly with distant sections of the country. In order to accomplish this, it was found necessary to increase the working potential of telegraph lines, and in its train came the demand for a better class of insulators.

During the battle between the demands of progress and the efforts of humanity to meet the imposed requirements, Mr. F. M. Locke was employed as a telegraph operator on a division of the New York Central & Hudson River Railroad, and also on the Pennsylvania Railroad Company. During wet and foggy weather he experienced difficulty in keeping the instruments which operated on the long lines in adjustment. On several occasions he was reported and censured for not answering his call. On one particular occasion Harrisburgh started to call him and he opened his key to answer, but found on closing it again that Harrisburgh was still calling. This puzzled him, as there was but one wire and that grounded at each end. Being of an inquisitive nature, he set out to determine the cause of such conditions, and found that the insulators were completely coated with a film of moisture, resulting from a fog. As this condition existed on a large number of insulators, the greater portion of the current returned to Harrisburgh through the shorter circuit by leakage over the surface of the insulators, and the opening of Mr. Locke's key did not interrupt Harrisburgh's circuit.

It naturally occurred to him that by increasing the surface length between the point of attachment of the wire and the cross arm, as well as the proper designing of the insulating surface, the tendency to surface leakage would be reduced. He started experimenting in a rather novel way with various kinds of insulators tied to the main line by the regular wire groove and a wire attached to the inner side of the pin hole, using his tongue as a galvanometer. After receiving several severe shocks from insulators with short surfaces, he was more careful in the selection of an insulator with a longer surface between the wire groove and the pin hole. This led up to the idea of increasing the number of petticoats and also increasing the diameter and lowering the height. The lowering of the height had the advantage of bringing the dripping edge closer to the cross arm and the increase in diameter brought it further away from the pin.. For further protection the middle petticoat was made to extend below the outer edge so as to further protect the inner petticoat and the pin. Patents were taken out by Mr. Locke covering the various improvements and the

credit must be given him for the pioneer work in the development of a multi-petticoat insulator, which has since been adopted for all high potential transmission circuits.

Dr. Louis Bell is quoted as having said that the best insulator is an ordinary five cent coffee cup, and in correspondence on the subject with Prof. Perrine, of Stanford University, he was informed that if the same amount of money had been expended in the perfection of the High Potential Porcelain Insulator, that had been expended in the perfection of manufacture of the five cent coffee cup, the product would now be more perfect and better suited to our needs.

Porcelain was used in the manufacture of insulators in order to get greater strength and to overcome the hygroscopic nature of glass insulators produced at that time. The production of a good porcelain was not well understood by our American manufacturers, and the first porcelain insulators produced were not as good as glass as far as insulating properties were concerned. Improvements have been made in the methods of manufacture and the following process has been found to give the best results.

The mixture is made up from a high grade of spar, which has been calcined and ground to a fine powder, finely ground flint of the best quality, and a quantity of the finest plastic white clay. This is thoroughly mixed together in wooden tanks with water, and then run over bolting cloth screens of a very fine mesh, to take out any coarse particles; it is then strained through a cloth to separate the "slip," as it is called, from the water. The slip is then dried to the proper degree and formed into insulators; then set away to dry sufficiently so they can be handled without destroying their shape. They are then placed in the upper part of the kiln and baked just enough to dry off the moisture. In this shape it is called a soft biscuit; this biscuit is then immersed in a mixture composed of the same material as the body of the insulator, but the proportions are varied by the use of a greater quantity of spar. After the biscuit has been immersed in this solution they are allowed to dry for a short time, and then put into the kiln and fired at a high heat. At this high temperature the water of absorption and crystalization is driven off and the greater quantity of spar in the surface mixture produces a perfect glaze of practically the same material as the body. An insulator produced in this way will not crackle or "craze" when exposed to variations of temperature. Great care must be used in annealing all insulators, as a sudden change from the high heat of the kiln would crack the glaze of the best porcelain. Insulators coated with a glazing similar to soft glass may pass test and be put on the line but after a year or so the surface may be found full of cracks, or crazed, and the accumulation of dust and dirt result in serious surface leakage.

A porcelain insulator should be vitrious through the entire body and the co-efficient of expansion of the surface material should be the same as that of the body. It is an open question as to the relative advantages of a poreclain insulator properly made, against a properly constructed glass insulator which has been properly annealed. It is claimed that the difference between the hygroscopic properties of porcelain and glass cannot be measured, and there seems to be good ground for this assertion.

After analyzing the great difficulties which are encountered in the manufacture of porcelain insulators, and the inefficiency of visual inspection, the glass insulator presents a better front in two particulars; it will not puncture, and defects are readily discernible with the eye. By the proper annealing of glass, the objection of extreme brittleness is removed. The question of leakage (if in excess of porcelain) can be overcome by proper cross arm and pin installation.

## SUPERIOR TO ANY JOURNAL PUBLISHED.

"Enclosed please find money order for $5.00, with which please keep my subscription to the Journal of Electricity going until said $5.00 runs out.

"I wish to express my appreciation of the very excellent articles published in your journal, and also of the illustrations, which I think superior to any journal published", writes Lewis Searing, Consulting Engineer of The Denver Engineering Works Company, of Denver, Colo.

## Personal

Mr. H. W. Goode, general manager of the Portland General Electric Company is in San Francisco.

Mr. Sidney Sprout and wife left San Francisco on the 15th for the East. They will be absent about a month.

Mr. S. Morgan Smith, of York, Pa., was among the visitors that attended the Sacramento Convention of the Electric Transmission Association.

Mr. F. F. Barbour, manager of the power and mining department of the San Francisco office of the General Electric Company, is now in the East.

Mr. A. E. Brooke Ridley has gone to London and will probably not return to San Francisco before early in December.

Mr. George D. Greenwood, manager of the California Electrical Works, has returned to San Francisco after an extended business trip throughout the East.

Mr. L. S. Boggs, electrical engineer of the Pioneer Electric Power Company, having completed the installation of that interesting transmission plant, recently spent a well-earned vacation in visiting the various electric transmission plants of California and Oregon.

Mr. J. A. Lighthipe, chief engineer for the Pacific Coast District of the General Electric Company, and who has been dangerously ill for several weeks past, has gone to Bartlett Springs, where his many friends sincerely hope he will find an immediate restoration to health.

Mr. A. P. Breyton, president of the Pelton Water Wheel Company and who has been confined to his home with pneumonia for nearly five months past, has recovered sufficiently to be about again and on November 2d, sailed for Honolulu, where he will winter.

# Telegraphy

## THE INFANCY OF THE TELEGRAPH.

An appreciation of the convenience that would arise from an ability to carry on conversation between distant points by means of pre-arranged signals is evidenced in history before the discovery of America, and even the ambition of the most advanced electricians of the present day to effect a system of telegraphing without wires was thought of (in a most primitive way, to be sure,)in the beginning of the sixteenth century. The first recorded suggestion for what may be termed "wireless telegraphy," aside from the references to be found in early Greek and Roman and possibly Chinese literature, is related by a Scotch contemporary to be the plan devised by Paracelsus, the alchemist (1493-1541), and described by the English "mystic," Robert Fludd (1574-1637,) who wrote:

Two friends who wished to converse at a distance proceeded thus: A piece of skin was cut from the arm of each, and these fragments were "transplanted," so that either party had a portion of the cuticle of the other engrafted on his person. When separated from each other, at a given hour one of them traced on the piece of alien skin with a metal point the letters of the words of his message, and his friend could read these letters on his own arm, no matter how far they were separated.

Another plan was referred to by Strada, the Italian historian (1572-1649), in "Prolusiones Academicae," published in 1617. He stated that two needles magnetized by the same loadstone retained sympathy no matter how far they were separated, and that deviations made by the one needle would be reproduced by the other. This idea of "sympathetic" magnet needles seemed to find much favor, as it was referred to in several scientific and philosophical treatises in the seventeenth century. Meanwhile the researches into the nature of electricity had been slowly progressing in France, Germany and Britain. It had been found that a current of electricity could be transmitted for a considerable distance through an iron or copper wire. In 1746 Le Monnier sent a current through an iron wire about 2,000 yards long. In the following year Dr. Watson transmitted a current across the Thames at Westminster Bridge, by dipping wires in the water and using the river as a conductor. But it had not occurred to anyone that this power might be used for signalling from one point to the other. The honor of suggesting this idea belongs of course to "an unknown Scotchman."

In the "Scot's Magazine" for February, 1753, a letter appeared dated "Renfrew, February 1, 1753," and signed "C. M." It was headed "An Expeditious Method of Conveying Intelligence." The anonymous writer proposed that a set of wires equal in number to the letters of the alphabet should be extended horizontally between two given points, and kept separate by being fixed at the ends in two plates of pierced glass. The wires were to project six inches beyond the glass plates, and a pith ball was to be suspended from every wire. About an eighth of an inch below the row of balls a case was to be laid containing the letters of the alphabet printed on thin paper. The operator at one end would transmit a current of electricity through one of the wires by connecting momentarily with an electrical machine and the pith ball at the other end would attract the thin paper with the printed letter. By manipulating the wires the words of a message could be spelled out. This writer further suggested as an alternative that bells might be used instead of the letters, and a signal alphabet could be constructed. "C. M." also suggested a coating for the wire in the following passage: "Some may perhaps think that although the electric fire has not been observed to diminish sensibly in its progress through any length of the wire that has been tried hitherto; yet as that has never exceeded some thirty or forty yards, it may be reasonably supposed that in a far greater length it would be remarkably diminished, and probably would be entirely drained off in a few miles by the surrounding air. To prevent the objection, and save longer argument, lay over the wires from one end to the other with a thin coat of jewelr's cement. This may be done for a trifle of additional expense, and as it is electric per se, will effectually secure any part of the fire from mixing with the atmosphere."

In 1765, a Genevan, Georges-Louis Lesage, devised a system of transmitting messages simjlar to the above method. His manuscript was submitted to Frederick the Great, but went astray at Berlin. It was not published until 1782. Five years afterwards Arthur Young stated that he had visited at Paris a mechanician called Lomond, who showed him a method of communicating messages from one part of the house to another by means of an electric wire. In 1796 Francisco Salva, of Madrid, proposed to signal between Bercelona and the island of Majorca by means of a sub-marine cable, using the electric machine; but at a later date he substituted the voltaic pile as his source of electrical energy. Soemmering suggested in 1809 that the galvanic battery should be used for this purpose; and he actually showed at Munich in that year a system of telegraphic signaling. About forty years before this time attention had been re-directed to the magnet needle as a means of communication. An Italian priest, named Beccaris, published a book in 1772 on "Artificial Electricity, in which he showed that electric circuits engendered magnetism. His theory was confirmed in 1802 by Romagnosi, of Trent; and in 1804 Dr. Mojon, of Genes, proved that unmagnetised needles acquired magnetic polarity when placed in a galvanic current. The way was thus prepared for Oersted, and in 1819 he announced his discovery of the deflection of the magnetic needle by an electric current, and showed how this phenomenon could be utilized for signalling at a distance.

# THE JOURNAL OF ELECTRICITY.

An Illustrated Review of the Industrial Applications of Electricity, Gas and Power.

OFFICIAL ORGAN OF THE PACIFIC COAST ELECTRIC TRANSMISSION ASSOCIATION.

SUBSCRIPTION PAYABLE IN ADVANCE. TERMS—DOMESTIC, ONE DOLLAR PER YEAR; FOREIGN, TWO DOLLARS PER YEAR.
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## EDITORIAL.

**TRANSMISSION AT 30,000 VOLTS.**

In discussing the proposed use of 33,000 volts on the transmission circuits of the Southern California Power Company, it was observed in those Columns some time since that "not a well grounded doubt has been expressed but that the undertaking will be crowned with success," and that the use of this high voltage for transmission purposes is now feasible is no longer a question of belief alone, for during a recent experimental run lasting three days, a potential as high as 30,000 volts was used continuously in actual work, under most trying climatic conditions. The experiment was made over the circuits of the Pioneer Electric Power Company of Ogden, under the direction of Mr. F. O. Blackwell, chief engineer of the power transmission department of the General Electric Company, and Mr. L. S. Boggs, electrical engineer of the Pioneer Company, from whom the following details of the experiments were derived.

A double pole line of three No. 1 wires extends from the powerhouse in Ogden Canon to Salt Lake City, a distance of 36½ miles. The transformers at the powerhouse and substations in Salt Lake City are connected in delta and are operated at a potential of approximately 15,000 volts at the powerhouse. For the purpose of experiment, however, these transformers were changed over from the delta to the star connections, and the electromotive force of the generator was also increased until a pressure of 30,000 volts was delivered to the line. At Salt Lake City the ends of the transmission lines was thus returned to the power house and delivered to a bank of three 250-kilowatt transformers which reduced the line pressure to 2,300 volts. This arrangement gave a transmission of seventy-three miles over which a load of 1,000 horse-power was delivered to the resistance vats at the power-house. The minimum potential delivered to the vats 27,880 volts, during which 23,000 volts pressure was delivered from the return circuit at the power-house. The water rheostats consisted of three wooden tanks, each measuring eight feet in length by three feet in depth by four feet in width. These tanks were placed five feet apart and mounted each on three double petticoat, deep groove glass insulators. The electrodes consisted of 3-8th sheet steel of such size as to give one inch clearance on all sides.

The loss in the transmission was measured by wattmeters inserted in both ends of the lines so as to include that due to the transformers (which together amounted to 4 per cent) and the maximum loss thus derived was 9.9 per cent. "There was no loss of voltage to speak of," writes Mr. Blackwell, "the capacity of the line (the periodicity is 60 cycles) being sufficient to compensate for the potential [inductive (?)—Ed.] drop." Mr. Blackwell further states that not the slightest difficulty of any kind developed during the entire seventy-two hours covering the test. During the experiment for a period of a day there was also taken from the circuit at Salt Lake City, at a pressure of 24,000 volts, a load of 500 horse-power consumed in operating synchronous motors.

To continue to quote from Mr. Blackwell's letter: "During this period there was the worst possible weather—rain, fog and snow alternating, with no trouble whatever, and in addition there was a severe thunder and lightning all of one night, during which the lightning arresters discharged repeatedly without causing even a flicker in the light circuits."

At the conclusion of the experiments the transformers were changed over from "Y" to delta windings, and since then the plant has been running at 15,000 volts as originally designed.

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**THREE COLOSSAL GENERATORS.**

The electrical press has recently described two large generators which are deserving of attention for their size and for other interesting features. The first is a three-phase dynamo, built by the General Electric Company for the Brooklyn Edison Company, and although it is rated at 1,500 kilowatts, it is stated that it is to be operated at 2,000 kilowatts output. It is of the revolving field type with forty poles; it is to be run at 75 revolutions per minute and will deliver a potential of 6,600 volts, and is to be direct driven by a four cylinder triple expansion engine.

The Brooklyn generator will deliver the high tension three-phase current to a system of conductors covering about 75 square miles of territory, and a large portion of the current will be transformed down to 375 volts and then, after passing through rotary converters, will be distributed at low voltage direct current to the three wire underground systems already receiving current from the stations now in operation. The remainder of the capac-

ity of the generator will be utilized by synchronous motors operating arc machines, as well as for various power purposes.

More noteworthy still in several respects are the Stanley generators being installed in the power plant of the Chambly Manufacturing Company at Richelieu Village, about twenty-five miles distant from Montreal, where the Richelieu River falls through a long series of rapids. The Chambly power-house is an integral part of the dam and is being erected for a capacity of 22,000 horsepower. The generators are direct coupled to horizontal shaft turbines and are of the usual inductor type of the Stanley Electric Manufacturing Company, and they are of especial interest in that they are built to deliver 2,000 kilowatts of 60-cycle, two-phase current at a potential of 12,000 volts. The bulk of the power will be consumed by the central station of the Royal Electric Company of Montreal.

These two generators, together with the remarkable Westinghouse machines at Niagara Falls, may be accepted as the most noteworthy productions of the three largest companies engaged in the manufacture of polyphase generators for the transmission of power, and each machine has distinctive points of peculiar interest. The 5,000 horsepower Westinghouse generators at Niagara Falls exceed all others in point of size, but their output is but 2,200 volts. The Brooklyn three-phaser is remarkable in being the first large generator of the revolving field type, but its potential being only 6,600 volts, is practically the same as has been in use by the three-phasers of the Portland General Electric Company for nearly three years past. It so happens, however, that neither the Brooklyn or the Portland plants require the use of step up transformers, which eliminates the introduction of a loss of some consequence into the transmission, but were it advisable to transmit current at a higher potential, neither the Westinghouse or the General Electric generators, in the light of present accomplishments, embody the advantage of extreme high voltage output as convincingly as it is to be found in the Stanley machines now being installed in the Chambly plant. The delivering of high voltage is one of the especial adaptabilities of inductor type machines and so eminently is it suited for this that the revolving field generators of the Niagara and Brooklyn installations seem, in comparison, as but steps in the evolution of the perfect polyphase dynamo electric machine.

## THE EFFICIENCY OF ILLUMINANTS.

Of the total energy supplied, a candle consumes 86 watts per candle; oil lamps, .57 watts; butterfly gas burner, 93 watts; incandescent lamp, 3.5 watts; arc lamp, 0.8 watts. Thus, if gas is used in a gas engine having an efficiency of 20 per cent, it will produce about five times more light from incandescent lamps than if burned direct in butterfly jets.—American Electrician.

# Passing Comment

*An Editorial Review of Current Events and Contemporary Publications.*

### A NUMBER WITHOUT ILLUSTRATIONS.

A profusely illustrated magazine, if brought out in a manner in keeping with the highest state of the art, is pleasing to the eye or may be necessary to a clear conception of a principle or situation, but sometimes hard information reciting experiences and convictions are more indispensible and these can only be set forth to advantage in the judicious combination of solid type, printer's ink, and good paper.

Of such is the present issue of The Journal of Electricity, and while its change in appearance may occasion comment, it certainly can not be adverse when it is known that those who prefer a liberal display of engravings are assured that their absence from this number does not indicate a permanent departure from the use of the usual illustrations that have become so prominent a feature of the style of the paper.

### WHEELS WITHIN WHEELS.

The San Gabriel Power Company has awarded the contract for the electrical machinery for the installation of its proposed 1,500 horsepower transmission plant, to the Westinghouse Electric & Manufacturing Company, and now speculation is rife as to whether the Westinghouse Company will find it to be the fiat of the Board of Control of the General Electric-Westinghouse "patent pool" that the contract must be turned over to the General Electric Company, as is said to have been done in the case of the contract for the Los Angeles equipment of the Southern California Power Company.

### SUCCESS IN ADVERTISING.

One of the most pleasing of the many attractive advertisements appearing in the street railway periodicals is that of the Standard Air-Brake Company. It is always new, always catchy and it is safe to say that when once read, it is read each month, even by the disinterested. So catchy is its tout ensemeble that one recognizes that the concern appreciates every detail of the fine art of advertising so thoroughly that he who has eyes is compelled to read, unless he be a dotard.

No wide-awake business man will pass unheeded the wise suggestion contained in a recent "ad" of the Standard Air-Brake Company, which, in discussing advertisements, observed:

"As a matter of fact, it's rather difficult to keep up a supply of fresh advertisements, when a solitary article like an air brake is the only thing to put before the public. But somehow we have to do it. Have to, because just as soon as we stop varying our ods, there's an abatement of inquiries.

"And it's inquiries we are after! Every man who

made an exhibit at Niagara Falls, and every man who invokes the aid of the press, does so with a view to getting inquiries. We all know that these are stepping stones to actual transactions."

Without doubt the advertisement which pays best is the one that is always fresh, crisp and to the point. It is well that the "ad" should always hold a certain space in the paper, but above all it should contain new matter so attractively presented that the reader will read the announcement as habitually as he does his morning paper. Indeed, did the morning papers contain the same matter, word for word and line for line, day after day and month after month, would they be read? Their variety, freshness and newsiness makes them invaluable, and as with newspapers, so with advertisements.

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THERE'S NO EXPERIMENT ABOUT IT.

On page 722 of the London "Electrician" for September 24th last, appears the following statement that, in the light of present knowledge regarding electrical transmission of power, and considering the source of the publication, is surprising:

"Mr. L. B. Stillwell, electrical director of Niagara Falls Power Company, says the transmission of 1,000 horsepower a distance of 26 miles is still an experiment, and until he has had actual experience in transmitting a block of 5,000 or 10,000 horsepower that distance, he has no opinion to express upon its efficiency."

The portion of the above relative to efficiency is rational, but the belief that it could not be the opinion of so eminent an engineer as Mr. Stillwell that "the transmission of 1,000 horsepower a distance of 26 miles is still an experiment," led the writer to call the paragraph to the attention of that gentleman and to solicit an expression of his views on the point for publication.

In reply, Mr. Stillwell wrote to The Journal of Electricity under date of October 18, 1897:

"The paragraph appearing in the London "Electrician" for September 24, 1897, must have been based upon a statement which I made in a letter written last July in reply to an inquiry for a large block of power. The inquiry came from a city at a very considerable distance from our power plant—a distance very much greater than 26 miles—and referring to the copy of my letter I find the following:

"The Niagara Falls Power Company is now transmitting 1,000 horsepower from Niagara Falls to the City of Buffalo—a distance of 26 miles— and we are gaining valuable experience in connection with this transmission. By January 1st, it is expected that 10,000 horsepower will be transmitted to that city over our lines, but until we have had actual experience in transmitting a block of 5,000 or 10,000 horsepower and have made complete tests of losses, etc., we shall not be ready to give positive information in regard to a proposed transmission over the much greater distance involved in conveying power to your city."

"The word 'experiment' was not used in my letter."

It is generous to opine that the paragraph quoted was "run in" on our esteemed London contemporary during a period when the editor slumbered and the office boy dominated the sanctum to the satisfaction of his own prankish humor.

THE ENGINEERING OF THE BLUE LAKES PLANT.

"The Electrical World," (Vol. XXX, No. 20) reprints a complete abstract of the description of the electric transmission plant of the Blue Lakes Water Company, appearing in the last issue of this publication, and in commenting on the installation, editorially observes:

In the plant of the Blue Lakes Water Power Company are two notable departures from customary engineering practice. The first is the complete absence of receivers, air-cushion chambers or relief valves of any kind on the pipe-line system. As the pipe line is some 3200 feet long, and has normally a head of 1000 feet at its lower end, with a velocity of flow of several hundred feet a minute when running at full capacity, the risk of omitting all relief measures would seem to be great. The engineer in charge has, however, evidently considered that prevention is better than cure, and instead of providing measures for relieving water hammer which depend for their action on the hammer itself, he has so designed his gates that the water cannot be shut off with sufficient rapidity to cause ramming. This necessarily forbids the use of governors controlling the flow of water, and the governors to be installed will regulate by diverting the stream from the wheel by means of hoods over the nozzles.

The other innovation is the use of direct-connected impulse wheels and generators, the shafts of which are hung on only two bearings the waterwheels and the flywheels being overhung at either end. The amost universal practice of underhanging such heavy wheels running at high speeds makes this a rather daring experiment. Considered theoretically, however, the overhung arrangement would seem to have considerable advantages over a shaft with similar loads supported by two bearings, one at either end, in that the shaft resists the bending stresses as does a beam, the overhanging ends acting as cantilevers and tending to balance loads applied on the underhung portion. Comparing the method used at Blue Lake City, with machines using three bearings, it must be remembered that dynamo shafts are necessarily very stiff, due to the enormous bending forces set up in case of any eccentricity of the armature in the field of force. To distribute the load on such a stiff shaft uniformly on three bearings the latter must be lined up with almost mathematical accuracy, a difficult thing to accomplish in some instances. Any deviation from perfect trueness in the shaft will also cause great vibratory strains in a shaft supported stiffly at three points. The lining up of two bearings is obviously perfect under all conditions, the use of spherically mounted brasses allowing also for any lack of trueness in the shaft. The overhanging weights on the ends of these shafts should give no more trouble, if perfectly balanced, in motion than in rest. To be sure, in addition to the weight of the water wheel there is added the force of the jets striking the buckets, but this force undoubtedly introduces strains much smaller than those in the crank shafts of an engine with overhung cranks.

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THE NEW PROBLEM IN TRANSPORTATION.

"Managing officers of steam railroads have been watching the inroads of the electric lines with great concern, and it is evident that prompt action must be taken or most of the suburban business will be transferred to the trolly lines," observes the American Engineer Car Builder and Railroad Journal in discussing the formidable competition that the development of electric traction has given rise to. Continuing, it points out that "ten years ago there was almost no electric traction. Now in the United States alone there is a trackage of nearly 14,000 miles. The increase in revenues is not less remark-

able, for we are told by Mr. Wm. J. Clark that a road 30 miles long, without increasing its trackage or making any other change except to substitute electric for horse traction, has increased its dividends from $60,000 in 1886 to $800,000 in 1896.

"The steam roads desire not only to offset the competition of the electric roads; they also want to derive the benefits now enjoyed by the trolly lines as the fruits of better service. One reason why it has been impossible to compare the cost of operation of steam and electric traction on the same road is the tendency for the electric equipment to stimulate travel and increase the volume of business. This is clearly shown by the reports of the increase in travel between Hartford, New Britain and Berlin over the electric line of the New England Railroad. The last year of the operation of steam on this line showed an average of 750 passengers per day.

"The number carried under the new plan at once jumped to high figures; the number for the first week, ending May 30, was 27,507, and for the following week 31,513. In the next week it was 20,000. These figures do not represent ordinary conditions because of the novelty of the line, which had a great influence on the amount of travel at first. The smallest number for a week has been 14,502, and for the week ending October 3 the number was 15,145, which may be taken as fairly representing the average conditions. The increase is due to several influences which are too well understood to require enumeration here."

Judging from the remaining portions of the editorial quoted, it does not appear that the steam lines will forego their long-loved steam locomotive for the electric motor without a serious effort to demonstrate that the steam dummy may be developed and perfected so that it will fulfill the conditions of the new problem as satisfactorily as is done by electricity. The fact of high economy in operation by electric traction seems to be generally accepted in railroad circles, but the deterrent to equipping existing steam lines with electricity lies in the financial burden of a change of power. For this reason, therefore, it appears to be the conclusion of many who are well posted in steam railway engineering that the solution of the problem will be found more readily in an adherance to the old method than in the adoption of the new one.

That this belief will bring forth adverse criticism, is not to be doubted and so far as the public is concerned, given two routes of travel in a modern electric line and in a rejuvenated steam dummy road, (ycleped "the smoky line") and it will not be slow to evidence its preference for the former. On the other hand, probably the acme of development of steam motors is to be found on the Manhattan elevated road, concerning the service of which the public never ceases to complain. Then again, the cost of an electric equipment is not so very great, considering its high efficiency and its popularity, and considering the low efficiency and the undetermined cost of experimenting upon the perfection of the steam dummy.

It is wisdom to go slow and be sure in the adoption of any revolutionizing methods in any industry of great magnitude, but the trend of the times points to the adoption of electricity on steam lines at an early date as being inevitable.

# Fraternal

## THE TRANSMISSION CONVENTION AT SACRAMENTO.

The second quarterly convention of the Pacific Coast Electric Transmission Association, was held in Sacramento on October 20-21, last and proved to be of unusual interest. The two themes for special consideration were "Protection Against Lightning," and "Hydraulic Problems," both of which elicited papers and discussions of great merit. The papers read are reproduced elsewhere in this issue, while the discussions will appear in the ensuing number.

The meetings were held in the parlors of the Golden Eagle Hotel on the evenings of the dates given and the second day of the session was devoted to an inspection of the extensive system of the Sacramento Electric, Gas and Railway Company, including a visit to the power house at Folsom. Mr. C. P. Gilbert, President of the Association and Manager of the Company, acted as host and despite the inclement weather, those present enjoyed a most agreeable and profitable day.

The next convention of the association will be held in San Francisco during the two days beginning February 20, 1898.

## "ON DIT."

**"Your paper is highly appreciated," writes Mr. E. A. Squire, of Represa, Cal.**

**"Allow us to compliment you on your fine editions. You deserve patronage."—Big Creek Power Company, Santa Cruz, Cal.**

## MATRIMONIAL.

Cards are out announcing the marriage of Mr. Ross Morgan to Miss Elizabeth Bodwell, in Lakeville, Cal., on October 13th last.

Though Mr. Morgan has long been well and favorably known in civil and municipal engineering throughout California, he has but recently come into prominence before the electrical engineering interests and the means of doing so were through his association on the staff of engineers engaged in the construction of the electrical transmission plant of the Blue Lakes Water Company. Mr. Morgan is one whose sincerity and geniality and ability makes friends for him on every hand and already he has won myriads of electrical friends who join the Journal of Electricity in wishing the newly mated couple the fullest measure of happiness and prosperity. The bride is the accomplished daughter of Mr. and Mrs C. A. Bodwell, of Lakeville.

# Industrial

*In Responding to Advertisements in this Publication, please mention "The Journal of Electricity."*

## A SUCCESSFUL ALTERNATING ARC LAMP.

The "Puritan" arc lamp during the past two years has been very widely adopted by central stations, as it embodies a number of features which heretofore have not been overcome in arc lighting. This type of lamp seems to obviate certain faults and failings of the old open arc. A prominent electrician who has been closely identified with some of the best construction work in America remarked the other day when looking at one of these lamps. "The difficulties encountered in the application of arc lamps to alternating-current circuits have largely been overcome since the present form of lamp has been on the market, and unquestionably the art of electric lighting has been more affected by these recent improvements than is appreciated by those who have considered this question."

The Puritan lamp, manufactured by the Puritan Electric Company of New York and Boston, is designed to burn upon a secondary voltage anywhere between 90 and 120 volts, and

taking six amperes of current, the total wattage of the lamp will range between 400 and 450, of which all but 25 watts are actually consumed at the arc in producing light. The mechanism is simple and not easily deranged, and 100 hours' life is obtained from the seven and one-half inches by one-half inch carbons, the upper and lower carbon being of the same length.

It is adaptable for use for both inside and outside lighting, and the humming and buzzing common to the old alternating arc has been entirely eliminated, making it unobjectionable in even the most confined quarters, while its short length makes it adaptable to the lowest ceilings.

No special transformers or economy coils are necessary, and the lamp is entirely self-contained and burns in multiple.

## A CHAPTER ON MICANITE.

Micanite is made of pure India sheet mica, joined together with a cement of very high resistance and it is recognized as the standard electric insulation. It can be shaped into almost any form desired and in a catalogue issued by the Mica Insulation Company of New York and San Francisco, they describe some of the purposes to which it has been put. Micanite is in use by the largest manufacturers of electric machinery, and by the electric street railways, and has given universal satisfaction. It is abreast with the times and is the only material adaptable to the high potential insulators of the present day.

On account of its high insulating qualities, Micanite can be used in places where inferior insulators would not be practicable, because of the thickness required by low grade materials to insulate.

It does not absorb oil or moisture—a great fault of inferior insulators—and its mechanical and electrical durability is unexcelled. It is equal in efficiency to India sheet mica and can be furnished in almost any form desired, thus effecting a great saving over the use of mica, when the labor entailed and the waste in mica are taken into consideration.

Mr. Franklin Brooks of New York, who is manager of the Mica Insulator Company, was in India recently and effected a combination whereby the Mica Insulator Company is in a position to furnish mica cheaper than any other concern in the United States. Moreover, in dealings with them, customers reach first hands and do not have to pay middle men's commissions. A large stock is carried in San Francisco, from which point all orders can be filled with dispatch.

The Mica Insulator Company is now placing on the market an insulating compound for the insulation and coating of all parts of motors, generators, armatures, field magnets, wires, cables, transformers, overhead line construction, arc lamps and switch boards, as well as on all bare metal surfaces. On cloth, paper, fuller board, etc., it has no equal. It is non-corrosive, and stands high temperature, it is impervious to moisture, has NO OFFENSIVE ODOR, is of full body and can be reduced to any desired density. Its price is very low.

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